



## Configuring X.25 on ISDN Using AO/DI

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The chapter describes how to configure the X.25 on ISDN using the Always On/Dynamic ISDN (AO/DI) feature. It includes the following main sections:

- [AO/DI Overview](#)
- [How to Configure an AO/DI Interface](#)
- [How to Configure an AO/DI Client/Server](#)
- [Configuration Examples for AO/DI](#)

AO/DI supports PPP encapsulation on switched X.25 virtual circuits (VCs) only.

The X.25 encapsulation (per RFC 1356), PPP, Bandwidth Allocation Control Protocol (BACP), and Bandwidth Allocation Protocol (BAP) modules must be present in both the AO/DI client and server.

AO/DI relies on features from X.25, PPP, and BACP modules and must be configured on both the AO/DI client and server. BAP, if negotiated, is a subset of BACP, which is responsible for bandwidth allocation for the Multilink PPP (MLP) peers. It is recommended you configure MLP with the BAP option due to the differences between the ISDN (E.164) and X.25 (X.121) numbering formats.

To implement AO/DI, you must configure the AO/DI client and server for PPP, incorporating BAP and X.25 module commands. This task involves configuring the BRI or PRI interfaces with the appropriate X.25 commands and the dialer interfaces with the necessary PPP or BAP commands.

To identify the hardware platform or software image information associated with a feature, use the Feature Navigator on Cisco.com to search for information about the feature or refer to the software release notes for a specific release. For more information, see the “Identifying Supported Platforms” section in the “Using Cisco IOS Software” chapter.

For a complete description of the commands in this chapter, refer to the [Cisco IOS Dial Technologies Command Reference](#), Release 12.2. To locate documentation of other commands that appear in this chapter, use the command reference master index or search online.

## AO/DI Overview

AO/DI functionality is based on the technology modules described in the following sections:

- [PPP over X.25 Encapsulation](#)
- [Multilink PPP Bundle](#)



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- [BACP/BAP](#)

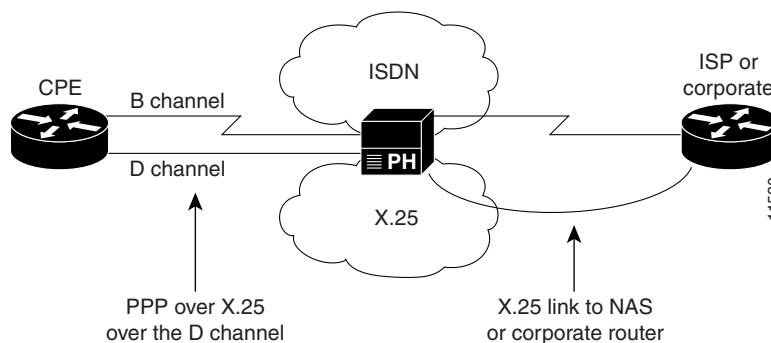
AO/DI is an on-demand service that is designed to optimize the use of an existing ISDN signaling channel (D channel) to transport X.25 traffic. The X.25 D-channel call is placed from the subscriber to the packet data service provider. The use of PPP allows protocols to be encapsulated within the X.25 logical circuit carried by the D channel. The bearer channels (B channels) use the multilink protocol without the standard Q.922 and X.25 encapsulations, and invoke additional bandwidth as needed. Optionally, BACP and BAP can be used to negotiate bandwidth allocation as required.

AO/DI takes full advantage of existing packet handlers at the central office by using an existing D channel to transport the X.25 traffic. The link associated with the X.25 D channel packet connection is used as the primary link of the multilink bundle. The D channel is a connectionless, packet-oriented link between the customer premise equipment (CPE) and the central office. Because the D channel is always available, it is possible to in turn offer “always available” services. On-demand functionality is achieved by using the B channels to temporarily boost data throughput and by disconnecting them after use. [Figure 1](#) shows the AO/DI environment and how ISDN and X.25 resources are implemented.

**Note**

On the client side, the X.25 switched virtual circuit (SVC) can only be terminated on an ISDN D channel; however, on the server side, the SVC can be terminated on an ISDN BRI using a D channel, a PRI using specific time slots, or a high-speed serial link.

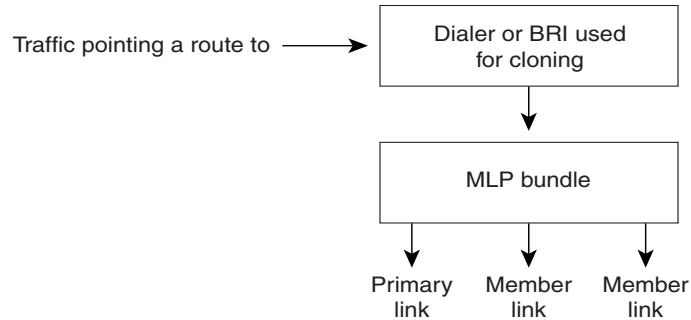
**Figure 1**      **AO/DI Environment**



AO/DI provides the following benefits:

- ISDN telecommuting cost savings. Low-speed, D-channel services are typically more cost-efficient than the time-based tariffs applied to the B channels, which usually carry user data.
- Reductions in the amount of data traffic from service provider voice networks. The D-channel X.25 packets are handled at the central office by the X.25 packet handler, thereby routing these packets bypassing the switch, which reduces impact on the telephony network.
- Network access server cost reductions. AO/DI can reduce service provider network access server costs by increasing port efficiencies. Initial use of the “always on” D-channel connection lowers the contention ratio on standard circuit switched dial ports. (See [Figure 2](#).)

**Figure 2** *Increasing Port Efficiency with AO/DI*

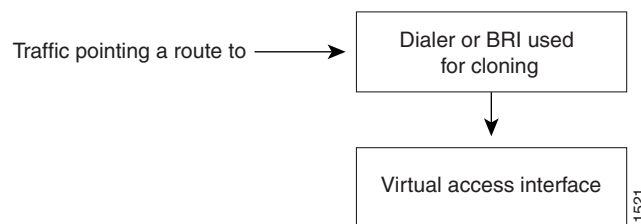


## PPP over X.25 Encapsulation

PPP over X.25 is accomplished through the following process:

1. The X.25 map statement on the client side creates a virtual access interface. A virtual access interface is dynamically created and configured by cloning the configuration from a dialer interface (dialer interface 1, for example).
2. The dialer interface goes into “spoofing” mode and stays in this mode until interesting traffic is seen.
3. When interesting traffic is seen, the dialer interface activates the virtual access interface, which creates the X.25 SVC. Once the SVC is established, PPP negotiation begins in order to bring up the line protocol. The client will initiate a call to the remote end server, per the **x25 map ppp** command.
4. When the AO/DI server receives a call intended for its X.25 map statement, the call is accepted and an event is queued to the X.25 encapsulation manager. The encapsulation manager is an X.25 process that authenticates incoming X.25 calls and AO/DI events, and creates a virtual access interface that clones the configuration from the dialer or BRI interface. [Figure 3](#) shows the virtual interface creation process.

**Figure 3** *Creating a Virtual Access Interface*



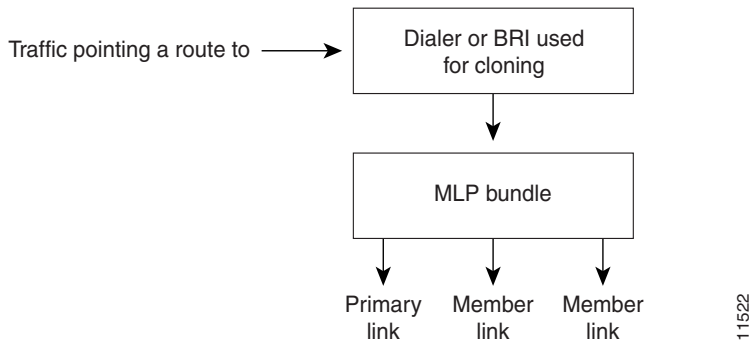
## Multilink PPP Bundle

The multilink protocol offers load balancing, packet fragmentation, and the bandwidth allocation functionality that is key to AO/DI structure. The MLP bundle process is achieved through the following process:

1. The **ppp multilink bap** command initiates MLP and, subsequently, BAP. The virtual access interface that is created above the X.25 VC (over the D channel) becomes the first member link of the MLP bundle.

- The **ppp multilink idle-link** command works in conjunction with the **dialer load-threshold** command in order to add B channels as needed to boost traffic throughput. When a B channel is added, the first member link enters “receive only” mode, allowing the link additions. When the higher throughput is no longer needed, the additional B channels are disconnected and the primary link is the only link in the bundle, the bundle disengages “receive only” mode. The X.25 SVC stays active. [Figure 4](#) shows the MLP bundle sequence.

**Figure 4** MLP Bundle Creation Sequence



## MLP Encapsulation Enhancements

In previous releases of the Cisco IOS software, when MLP was used in a dialer profile, a virtual access interface was always created as the bundle. It was bound to both the B channel and the dialer profile interfaces after creation and cloning. The dialer profile interface could act as the bundle without help from a virtual access interface. But with recent software enhancements, it is no longer the virtual access interface that is added into the connected group of the dialer profile, but the dialer profile itself. The dialer profile becomes a connected member of its own connected group.

## BACP/BAP

Bandwidth resources are provided by BACP, described in RFC 2125. Once the MLP peers have successfully negotiated BACP, BAP negotiates bandwidth resources in order to support traffic throughput. BAP is a subset of BACP, and it defines the methods and governing rules for adding and removing links from the bundle for MLP. BACP/BAP negotiations are achieved through the following process:

- Once the MLP session is initiated and BACP is negotiated over the MLP bundle, the AO/DI client issues a BAP call request for additional bandwidth.
- The AO/DI server responds with the BAP call response, which contains the phone number of the B channel to add. B channels are added, as needed, to support the demand for increased traffic throughput.
- B channels are disconnected as the traffic load decreases.

## How to Configure an AO/DI Interface

To configure X.25 on ISDN using AO/DI, perform the following tasks:

- [Configuring PPP and BAP on the Client](#) (As required)

- [Configuring X.25 Parameters on the Client](#) (As required)
- [Configuring PPP and BAP on the Server](#) (As required)
- [Configuring X.25 Parameters on the Server](#) (As required)

For examples of how to configure X.25 on ISDN using AO/DI in your network, see the section “[Configuration Examples for AO/DI](#)” at the end of this chapter.

## Configuring PPP and BAP on the Client

To configure PPP and BAP under the dialer interface on the AO/DI client, use the following commands in interface configuration mode as needed:

Command	Purpose
Router(config-if)# <b>ppp multilink bap</b>	Enables PPP BACP bandwidth allocation negotiation.
Router(config-if)# <b>encapsulation ppp</b>	Enables PPP on the interface.
Router(config-if)# <b>dialer in-band</b>	Enables dial-on-demand routing (DDR) on the interface.
Router(config-if)# <b>dialer load-threshold load</b>	Sets the dialer load threshold.
Router(config-if)# <b>dialer-group group-number</b>	Controls access to this interface by adding it to a dialer access group.
Router(config-if)# <b>ppp bap callback accept</b>	(Optional) Enables the interface to initiate additional links upon peer request.
Router(config-if)# <b>ppp bap call request</b>	Enables the interface to initiate additional links.
Router(config-if)# <b>dialer map protocol</b> <i>next-hop-address [name hostname] [spc] [speed 56   speed 64] [broadcast] [modem-script modem-regexp] system-script system-regexp</i>	Enables a serial interface or an ISDN interface to initiate and receive calls to or from remote sites.
or	
Router(config-if)# <b>dialer string dial-string</b> [: <i>isdn-subaddress</i> ]	Specifies the destination string (telephone number) for calling:
Router(config-if)# <b>dialer string dial-string [class class-name]</b>	<ul style="list-style-type: none"> <li>• A single site (using legacy DDR)</li> <li>• Multiple sites (using dialer profiles)</li> </ul>

## Configuring X.25 Parameters on the Client

The AO/DI client interface must be configured to run PPP over X.25. To configure the interface for the X.25 parameters, use the following commands in interface configuration mode as needed:

Command	Purpose
Router(config-if)# <b>x25 address address</b>	Configures the X.25 address.
Router(config-if)# <b>x25 htc circuit-number</b>	Sets the highest two-way circuit number. For X.25 the default is 1024.

Command	Purpose
Router(config-if)# <b>x25 win</b> <i>packets</i>	Sets the default VC receive window size. The default is 2 packets. <sup>1</sup>
Router(config-if)# <b>x25 wout</b> <i>packets</i>	Sets the default VC transmit window size. The default is 2 packets. <sup>1</sup>

1. The default input and output window sizes are typically defined by your network administrator. Cisco IOS configured window sizes must be set to match the window size of the network.

For details and usage guidelines for X.25 configuration parameters, refer to the *Cisco IOS Wide-Area Networking Configuration Guide* and *Cisco IOS Wide-Area Networking Command Reference*.

## Configuring PPP and BAP on the Server

To configure PPP and BAP under the dialer interface on the AO/DI server, use the following commands in interface configuration mode as needed:

Command	Purpose
Router(config-if)# <b>ppp multilink bap</b>	Enables PPP BACP bandwidth allocation negotiation.
Router(config-if)# <b>encapsulation ppp</b>	Enables PPP on the interface.
Router(config-if)# <b>dialer in-band</b>	Enables DDR on the interface.
Router(config-if)# <b>dialer load-threshold</b> <i>load</i>	Sets the dialer load threshold.
Router(config-if)# <b>dialer-group</b> <i>group-number</i>	Controls access to this interface by adding it to a dialer access group.
Router(config-if)# <b>ppp bap call accept</b>	Enables the interface to accept additional links upon peer request.
Router(config-if)# <b>ppp bap callback request</b>	Enables the interface to initiate additional links (optional).

BAP configuration commands are optional. For information on how to configure BACP/BAP see the chapter “Configuring BACP” later in this publication.

## Configuring X.25 Parameters on the Server

The AO/DI server BRI, PRI, or serial interface must be configured for the X.25 parameters necessary to run PPP over X.25. To configure the interface for X.25 parameters, use the following commands in interface configuration mode as needed:

Command	Purpose
Router(config-if)# <b>x25 address</b> <i>address</i>	Configures the X.25 address.
Router(config-if)# <b>x25 htc</b> <i>circuit-number</i>	Sets the highest two-way circuit number. For X.25 the default is 1024.

Command	Purpose
Router(config-if)# <b>x25 win</b> <i>packets</i>	Sets the default VC receive window size. The default is 2 packets. <sup>1</sup>
Router(config-if)# <b>x25 wout</b> <i>packets</i>	Sets the default VC transmit window size. The default is 2 packets. <sup>1</sup>

1. The default input and output window sizes are typically defined by your network administrator. Cisco IOS configured window sizes must be sets to match the window size of the network.

For details and usage guidelines for X.25 configuration parameters, see the *Cisco IOS Wide-Area Networking Configuration Guide* and *Cisco IOS Wide-Area Networking Command Reference*.

## How to Configure an AO/DI Client/Server

Once the AO/DI client and server are configured with the necessary PPP, BAP, and X.25 commands, configure the routers to perform AO/DI. Perform the tasks in the following sections:

- [Configuring the AO/DI Client](#) (Required)
- [Configuring the AO/DI Server](#) (Required)

### Configuring the AO/DI Client

To configure AO/DI, you must complete the tasks in the following section. The last task, to define local number peer characteristics, is optional.

- [Enabling AO/DI on the Interface](#) (Required)
- [Enabling the AO/DI Interface to Initiate Client Calls](#) (Required)
- [Enabling the MLP Bundle to Add Multiple Links](#) (Required)
- [Modifying BACP Default Settings](#) (Optional)

See the section “[AO/DI Client Configuration Example](#)” at the end of this chapter for an example of how to configure the AO/DI client.

### Enabling AO/DI on the Interface

To enable an interface to run the AO/DI client, use the following command in interface configuration mode:

Command	Purpose
Router(config-if)# <b>x25 aodi</b>	Enables the AO/DI client on an interface.

### Enabling the AO/DI Interface to Initiate Client Calls

You must enable the interface to establish a PPP session over the X.25 protocol. The cloning interface will hold the PPP configuration, which will be cloned by the virtual access interface that is created and attached to the X.25 VC. The cloning interface must also hold the MLP configuration that is needed to run AO/DI.

To add the X.25 map statement that will enable the PPP session over X.25, identify the cloning interface, and configure the interface to initiate AO/DI calls, use the following command in interface configuration mode:

Command	Purpose
Router(config-if)# <b>x25 map</b> <i>ppp x121-address</i> <b>interface</b> <i>cloning-interface</i>	Enables the interface to initiate a PPP session over the X.25 protocol and remote end mapping.

## Enabling the MLP Bundle to Add Multiple Links

Once MLP is enabled and the primary traffic load is reached (based on the **dialer load-threshold** value), the MLP bundle will add member links (B channels). The addition of another B channel places the first link member into “receive-only” mode and subsequent links are added, as needed.

To configure the dialer interface or BRI interface used for cloning purposes and to place the first link member into receive only mode, use the following command in interface configuration mode:

Command	Purpose
Router(config-if)# <b>ppp multilink</b> <i>idle-link</i>	Configures the interface to enter “receive only” mode so that MLP links are added as needed.

## Modifying BACP Default Settings

During BACP negotiation between peers, the called party indicates the number to call for BACP. This number may be in either a national or subscriber format. A national format indicates that the phone number returned from the server to the client should contain ten digits. A subscriber number format contains seven digits.

To assign a prefix to the phone number that is to be returned, use the following optional command in interface configuration mode:

Command	Purpose
Router(config-if)# <b>ppp bap</b> <i>number prefix</i> <i>prefix-number</i>	(Optional) specifies a primary telephone number prefix for a peer to call for PPP BACP negotiation.



### Note

The **ppp bap number prefix** command is not typically required on the server side, as the server usually does not initiate calls to the client. This command would only be used on the server in a scenario where both sides are configured to act as both client and server.

## Configuring the AO/DI Server

The AO/DI server will receive calls from the remote end interface running AO/DI client and likewise, and must be configured to initiate a PPP session over X.25, allow interface cloning, and be capable of adding links to the MLP bundle. The interface configured for AO/DI server relies on the **no-outgoing** option for the **x25 map** command to ensure calls are not originated by the interface. Use the commands in the following sections to configure the AO/DI server:



- [Enabling the Interface to Receive AO/DI Client Calls](#) (Required)
- [Enabling the MLP Bundle to Add Multiple Links](#) (Required)
- [Modifying BACP Default Settings](#) (Optional)

See the section “[AO/DI Server Configuration Example](#)” at the end of this chapter for an example of how to configure the AO/DI server.

## Enabling the Interface to Receive AO/DI Client Calls

Configure the **x25 map** command with the X.121 address of the calling client. This task enables the AO/DI server interface to run a PPP over X.25 session with the configured client. The **no-outgoing** option must be set in order to ensure that calls do not originate from this interface.

To configure an interface for AO/DI server, use the following command in interface configuration mode:

Command	Purpose
Router(config-if)# <b>x25 map ppp x121-address</b> <b>interface cloning-interface no-outgoing</b>	Enables the interface to initiate a PPP session over the X.25 protocol and remote end mapping.

## Enabling the MLP Bundle to Add Multiple Links

Once MLP is enabled and the primary traffic load is reached (based on the **dialer load-threshold** value), the MLP bundle will add member links (B channels). The addition of another B channel places the first link member into “receive-only” mode and subsequent links are added, as needed.

To configure the dialer interface or BRI interface used for cloning purposes and to place the first link member into receive only mode, use the following command in interface configuration mode:

Command	Purpose
Router(config-if)# <b>ppp multilink idle-link</b>	Configures the interface to enter “receive only” mode so that MLP links are added as needed.

## Modifying BACP Default Settings

During BACP negotiation between peers, the called party indicates the number to call for BACP. This number may be in either a national or subscriber format. A national format indicates that the phone number returned from the server to the client should contain 10 digits. A subscriber number format contains 7 digits.

To assign a prefix to the phone number that is to be returned, use the following, optional command in interface configuration mode:

Command	Purpose
Router(config-if)# <b>ppp bap number {format</b> <b>national   subscriber}</b>	(Optional) Specifies that the primary telephone number for a peer to call is in either a national or subscriber number format.

**Note**

The **ppp bap number prefix** command is not typically required on the server side, because the server usually does not initiate calls to the client. This command would only be used on the server in a scenario where both sides are configured to act as both client and server.

## Configuration Examples for AO/DI

This section provides the following configuration examples:

- [AO/DI Client Configuration Example](#)
- [AO/DI Server Configuration Example](#)

### AO/DI Client Configuration Example

The following example shows BRI interface 0 configured with the PPP, multilink, and X.25 commands necessary for the AO/DI client:

```
hostname Router_client
!
ip address-pool local
isdn switch-type basic-5ess
x25 routing
!
interface Ethernet0
 ip address 172.21.71.99 255.255.255.0
!
interface BRI0
 isdn switch-type basic-5ess
 ip address 10.1.1.9 255.0.0.0
 encaps ppp
 dialer in-band
 dialer load-threshold 1 either
 dialer-group 1
 no fair-queue
 ppp authentication chap
 ppp multilink bap
 ppp bap callback accept
 ppp bap call request
 ppp bap number prefix 91
 ppp multilink idle-link
 isdn x25 static-tei 23
 isdn x25 dchannel
 dialer rotary-group 1
!
interface BRI0:0
 no ip address
 x25 address 12135551234
 x25 aodi
 x25 htc 4
 x25 win 3
 x25 wout 3
 x25 map ppp 12135556789 interface bri0
!
dialer-list 1 protocol ip permit
```

## AO/DI Server Configuration Example

The following example shows the configuration for the AO/DI server, which is configured to only receive calls from the AO/DI client. The configuration uses the **x25 map ppp** command with the **no-outgoing** option, and the **ppp bap number format** command, which implements the **national** format.

```
hostname Router_server
!
ip address-pool local
isdn switch-type basic-5ess
x25 routing
!
interface Ethernet0
 ip address 172.21.71.100 255.255.255.0
!
interface BRI0
 isdn switch-type basic-5ess
 ip address 10.1.1.10 255.0.0.0
 encaps ppp
 dialer in-band
 no fair-queue
 dialer load-threshold 1 either
 dialer-group 1
 ppp authentication pap
 ppp multilink bap
 ppp multilink idle-link
 ppp bap number default 2135550904
 ppp bap number format national
 ppp bap call accept
 ppp bap timeout pending 20
 isdn x25 static-tei 23
 isdn x25 dchannel
 dialer rotary-group 1
!
interface BRI0:0
 no ip address
 x25 address 12135556789
 x25 htc 4
 x25 win 3
 x25 wout 3
 x25 map ppp 12135551234 interface bri0 no-outgoing
!
dialer
```

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